AC 2009-1210: A COLLABORATIVE CURRICULUM DEVELOPMENT TO IMPROVE CHINESE STUDENT LEARNING OUTCOMES

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A Collaborative Curriculum Development to Improve Chinese Student Learning Outcomes

Abstract

This paper presents an initiative of an engineering curriculum enhancement and an example of collaborative junior student’s project development, based on the enhanced curriculum. The main goal of this research is to integrate the best practices from the American engineering education programs into existing engineering curriculum, and to study the effectiveness of the enhancement, made up of a number of new focus areas in critical thinking and practical problem solving.

The research is carried out to study the feasibility and effectiveness of newly designed project collaborations between an American professor and a Chinese student, involved in a junior project. American professor helps to integrate successful American engineering education experiences into Chinese undergraduate engineering curriculum, and guides Chinese students in the project development to enforce the new enhancements in the student’s project.

This study executes a comprehensive test plan in a junior software development project, to research the feasibility of the curriculum enhancement. Also, it measures the effectiveness of student learning in the areas of critical thinking and practical problem solving. Modifications of teaching methods are made as the project progresses. At the end of the project student learning performance is evaluated, using various methods, such as observation, interview, survey and report. The survey results are processed with the help of statistical methods and software. Calculated results are analyzed to measure effectiveness of curriculum enhancements, to assist Chinese engineering students in learning, in the areas of critical thinking and practical problem solving. Then, the results are utilized to create new guidelines for future curriculum improvement. Some drawbacks are also discovered while doing survey analysis, and future improvement plan is recommended.

Introduction

A recent Alumni survey discovers that the majority of Chinese engineering students spent most of their time working on technically challenging projects in their undergraduate study. However, most of alumni complained that their undergraduate study, particularly their junior and senior projects, did not benefit their professional work significantly. Although most of the junior/senior college projects were considered as technically advanced, knowledge and experience gained from them had not met their needs in the areas of critical thinking and problem solving, which were required in their professional work. Other interesting findings, based on the results of evaluation and assessment in a number of surveys on existing engineering curriculum, are summarized below:

1. 80 percent of surveyors stated that their projects were difficult and challenging to a junior or a senior student.
2. 95 percent of projects solely focused on technical difficulty, and required students to devote most of their time and energy on solving technical problems.

3. 54 percent of projects were closely related to other course works. Students simply utilized what they had learned in their course work, and rarely had any chance to develop their critical thinking and problem solving skills from the project development.

4. 56 percent of students did not feel that they had gained any experience beneficial to their professional career, because the invented technology had already become outdated by the time of their graduation, or because their current work is not directly related to their undergraduate projects.

5. 88 percent of responses expressed a desire to gain practical knowledge and individual development skills, such as critical thinking, problem solving, project management, human development skills, and leadership, and to focus on those in their undergraduate engineering curriculum, particularly junior and senior projects.

**Problems and Goals of Changes**

In order to identify needed enhancement for the existing curriculum, the following principles and criteria are used as guidelines to determine appropriate changes and enhancements in the curriculum:

1. Main purpose of junior and senior engineering students’ projects is to provide them with opportunities to develop their knowledge and skills that will be beneficial in their professional career.
2. Most of knowledge and skills that students obtain from undergraduate study can be applied to their professional career.
3. Emphasis on new technology in junior and senior projects should be shifted to developing practical knowledge and skills.
4. Certain successful methods in the existing curriculum should remain.

Obviously, the main goal of any engineering program is to prepare engineering students for their professional career in the global economy. By the time of the graduation these students should not only know how to solve technical problems, but also be able to deal with problems beyond the scope of technology.  

A recent research discovered that students benefit from so-called practical knowledge in their professional career. The research also found that obtaining practical knowledge from college study is more beneficial to the professional career of students than mastering any new technology. Another interesting finding was that training students to gain practical knowledge can be integrated into an existing curriculum.

Numerous researches have found that today’s technology can become obsolete soon, compared to ten or twenty years ago. Although learning technology has always been an important component of any engineering curriculum, it is unwise to have it as the only focus in the engineering curriculum. Emphasizing advanced level in technology and forcing students to spend majority of their time on learning and mastering new technology can decrease the effectiveness level of the program.
The authors conducted a survey among the graduates and use a statistic, mean to measure average score of opinions from about 200 sample data (a summary of survey results is listed in Table 1 below). In the survey, many students mention lack of substantial training on the human development skills during the course of their college study. The results of the survey support suggestions from the research, previously conducted by one of authors of this research paper. Another report on curriculum study also contains similar finding, i.e. most of curricula should have sufficient emphases on training on human development skills, such as communication, organizational behavior, planning, project management, and problem solving skills. Overemphasis on technology and lack of training on practical knowledge and human development skills have existed in engineering undergraduate curricula for a quite long time. Addressing this critical issue and developing an enhancement for the undergraduate engineering curriculum are imminent.

Table 1: Summarized Result from Student Surveys

<table>
<thead>
<tr>
<th>Survey from Chinese Engineering Students</th>
<th>Average Points (up to 100 points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which skill obtained from your college study is beneficial to your professional career?</td>
<td></td>
</tr>
<tr>
<td>• Classroom Participation</td>
<td>85.3</td>
</tr>
<tr>
<td>• Classroom Discussion</td>
<td>60.7</td>
</tr>
<tr>
<td>• Self-Motivation Encouragement</td>
<td>75.5</td>
</tr>
<tr>
<td>• Leadership</td>
<td>94.1</td>
</tr>
<tr>
<td>• Time Management Skills</td>
<td>91.3</td>
</tr>
<tr>
<td>• Team Management and Coordination</td>
<td>87.8</td>
</tr>
<tr>
<td>• Cross-cultural Experience</td>
<td>75.5</td>
</tr>
<tr>
<td>• Problem Analysis and Solving</td>
<td>87.3</td>
</tr>
<tr>
<td>• Critical Thinking</td>
<td>95.5</td>
</tr>
<tr>
<td>• Mathematics Skills</td>
<td>88.5</td>
</tr>
<tr>
<td>• Communication and Presentation Skill</td>
<td>82.0</td>
</tr>
<tr>
<td>• Technology</td>
<td>77.3</td>
</tr>
</tbody>
</table>

These results can also be used to determine the focus of the curriculum enhancement. Therefore, training on practical knowledge and human development skills, particularly critical thinking and problem solving, are definitely needed in undergraduate engineering curriculum.

**Practical Knowledge and Skills for Curriculum Enhancement**

A recent research reveals the importance of acquiring practical knowledge and development of self-regulation skills during the college study. The research also suggests that appropriate instructional support and optimal levels of control over the learning processes, enhanced by self-explanation and self-visualization techniques, may enhance learner’s abilities to apply knowledge and skills to student’s work.
According to “Transferable Skills Survey”, published by Knowledge Management Center at University of Minnesota, over the years a student develops many skills from coursework, extracurricular activities, and his/her general life experiences. A student uses these skills while researching, writing, editing, and presenting papers for various classes. More importantly, this set of skills is not limited to any academic discipline, knowledge area, or college study, but is built up and applied to professional career. A prospective employer expects a graduate to be able to apply all the skills that he/she has learned in college to the work environment. This survey has become the foundation for identifying and selecting needed knowledge and human development skills to be applied in the undergraduate engineering curriculum (particularly junior and senior projects).

Four broad knowledge and skill areas are identified and can be further divided into more specific skills as follows:

**Communication** is the expression, transmission and interpretation of knowledge and ideas.
- Speaking effectively
- Writing concisely
- Listening attentively
- Expressing ideas
- Facilitating group discussion
- Providing appropriate feedback
- Negotiating
- Perceiving nonverbal messages
- Persuading
- Reporting information
- Describing feelings
- Interviewing
- Editing

**Research & Planning** is the search for specific knowledge and the ability to conceptualize future needs and solutions for meeting those needs.
- Forecasting, predicting
- Creating ideas
- Identifying problems
- Imagining alternatives
- Identifying resources
- Gathering information
- Solving problems
- Setting goals
- Extracting important information
- Defining needs
- Analyzing
- Developing evaluation strategies
**Human Relations** is the use of interpersonal skills for resolving conflict, relating to and helping people.
- Developing rapport
- Being Sensitive
- Listening
- Conveying feelings
- Providing support for others
- Motivating
- Sharing credit
- Counseling
- Cooperating
- Delegating with respect
- Representing others
- Perceiving feelings, situations
- Asserting

**Organization, Management and Leadership** is the ability to supervise, direct and guide individuals and groups in the process of completion of tasks and fulfillment of goals.
- Initiating new ideas
- Handling details
- Coordinating tasks
- Managing groups
- Delegating responsibility
- Teaching
- Coaching
- Counseling
- Promoting change
- Selling ideas or products
- Decision making
- Managing conflict

The research concludes that knowledge and skills listed above are the key factors to the success in professional career. Other researches also support this conclusion, and some even indicate that these skills can be obtained from college study and be carried over to professional career, to maximize life-long learning benefits of the training, designed in undergraduate projects.

**New Focuses in the Curriculum**

Although developing professional skills is a life-long learning process, it is more beneficial if a student starts to develop them in his/her early stage of learning, such as an undergraduate program. More importantly, these skills never become obsolete, because they can be applied to student’s future professional career. It would be natural and appropriate to add a systematic solution and method, with new focus on practical knowledge and human development skills, to existing undergraduate engineering curriculum. Based on findings from the research above, and
as an initiative of the curriculum development project, a set of practical knowledge and human development skills were integrated into the existing engineering curriculum.

Since students can easily acquire knowledge and develop self-regulation skills out of their junior and senior projects, it is appropriate to plan new curriculum enhancement in junior and senior projects. The multi-dimensional objectives in a junior student project are designed to connect numerous stakeholders with diverse interests. The student benefits from practice-oriented interventions by his peers and particularly their instructors. Diverse cultures from different organizations and professional levels develop student’s capacity-building, and even without any concentration or core in project management, open- relations between partners can really encourage innovations.

Due to limitation of available resources, three categories of practical knowledge and skills are identified as new focus areas in the curriculum enhancement. These changes will address and deal with the weak sides of the undergraduate engineering program in China.

The enhancement is integrated into students’ project design and planning, project resource planning, process issue handling, and project management and monitoring.

1. Enhancement of project design and planning – This new focus is specific knowledge and the ability to conceptualize future needs and solutions for meeting those needs:
   - Identifying problems
   - Creating ideas and imagining alternatives
   - Gathering information and identifying resources
   - Developing methods for solving problems
   - Extracting important information
   - Defining needs and goals
   - Forecasting project milestone based on goals

2. Enhancement of project resource planning and process issue handling – This new focus is to develop special skills, which assist in promoting problem solving and effective communication:
   - Making proper judgments and critical decisions
   - Being punctual and decisive
   - Accepting responsibility
   - Coordinating works among multiple teams

3. Enhancement of project management and monitoring – This new focus is to improve the day-to-day skills, which assist in promoting effective production and work satisfaction:
   - Implementing decisions and enforcing policies
   - Managing time, setting and meeting deadlines
   - Meeting goals
   - Organizing
   - Experience evaluation and gathering
Experiment on the Curriculum with New Enhancements

The experiment and evaluation of the curriculum with new enhancements were carefully planned and carried out. The feasibility of this new curriculum model shall first be tested and then evaluated, to know whether or not the new model of networked knowledge is applicable and student learning with others, instead of without others, works. Emphasis on student initiative, their role, participation and cooperation with instructors is first experimented.

Prior to this change, traditional projects did not require any student decision-making or any instructor involvement in every phase of project development. With new focus on student’s roles and involvement in decision making process, a new role and participation structure is developed, to require both student and instructor to work actively on joint decision making through the entire project development, in order to provide students with unique opportunities to promote their own ideas in critical decision making, and manage social mix among cooperative members. This new diversity management model requires a student to make more critical decisions under guidance of his/her instructor.

Another change to be tested was a new social environment and cultural activities among students and instructors. A newly developed communication model was expected to allow a student to freely communicate with his/her instructor and encourage a student to focus on working with any available resource, and seeking cooperation from his/her instructor and other students. As a result, a new informal participation structure with different kinds of participants, instructors, teaching assistants and other students was formed. This new diversity management model also combined participants and multiple communitarian channels together, in order to target managing social mix, in cooperative working environment.

This improvement decentralized a project to become multi-dimensional. More parties became involved in project development, instead of simple “one student - one instructor” hierarchical model. The improvement also involved a large number of key participants, such as instructors, teaching assistants and other students turn a project into a peer team effort. This change also promoted student’s creativity and innovation, rather than maintaining the old mainstream activities for a short-term benefit. Due to the fact that most of Chinese students are used to be permissive, this part had to be tested thoroughly, before the enhancement became an official part of the new curriculum.

The expected outcomes of the experiment also included testing whether or not new curriculum enhancement would revitalize cooperation among members of project development teams, and promote innovation in the newly founded cooperation between students and instructors. The new roles demanded group members to commit their work for the team and encouraged organizational networking, synergies and partnerships. Most importantly, it will validate proposal of curriculum enhancement, and help to develop new guidelines for future curriculum development.

A junior student project was set to as a pilot test for new curriculum enhancements. This junior student was instructed to develop a digital controlled outdoor temperature monitoring and
display system. An American professor was assigned to be his advisor throughout the entire project. In addition, the professor had to ensure that the new curriculum enhancement was fully implemented and tested in this project. Since the American professor could only communicate with his student via email and Skype, a PhD student was recruited to work as a teaching assistant, on the behalf of American professor throughout the project, in order to keep a close contact with the student, promote more diversity, and test and evaluate the new curriculum changes, applied in the project. Based on the enhanced curriculum new tasks were added to student’s project task list:
1. Budget
2. Cost analysis
3. Project management
4. Project tracking
5. Communication
6. Presentation

A number of examples of students work demonstrated successful execution and achievement of the curriculum enhancement. This student learned to use simple software tool like Excel to plan, monitor, track, report, and coordinate his project development. The project budget tracking form below was used by the student to plan and manage his resources throughout the project. It was also used to track and report status of his project development, particularly project cost analysis and budget. His final report showed that this new addition developed his knowledge and experience and he had mastered basic concepts and key skills in project resource planning and project management.

Table 2: Dynamic Project Cost Analysis and Budget Tracking Sheet as of Week 4

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2500</td>
<td>500</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1000</td>
<td>250</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>200</td>
<td>250</td>
<td>250</td>
<td>400</td>
<td>200</td>
<td>250</td>
<td>250</td>
<td>400</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>250</td>
<td>250</td>
<td>400</td>
<td>200</td>
<td>3750</td>
<td>1000</td>
<td>1150</td>
</tr>
</tbody>
</table>

| Actuals  |        |        |        |        |        |        |        |        |
| Hardware |        |        |        |        | 200    | 250    | 250    | 400    |
| Software |        |        |        |        | 200    | 250    | 250    | 400    |
| Labor    | 200    | 250    | 250    | 400    | 200    | 3750   | 1000   | 1150   |
| Total    | 200    | 250    | 250    | 400    | 200    | 3750   | 1000   | 1150   |

| Weekly   |        |        |        |        |        |        |        |        |
| Hardware |        |        |        |        | 200    | 250    | 250    | 400    |
| Software |        |        |        |        | 200    | 250    | 250    | 400    |
| Labor    | 200    | 250    | 250    | 400    | 200    | 3750   | 1000   | 1150   |
| Total    | 200    | 250    | 250    | 400    | 200    | 3750   | 1000   | 1150   |

| Cum +/-  |        |        |        |        |        |        |        |        |
| Hardware |        |        |        |        | 200    | 250    | 250    | 400    |
| Software |        |        |        |        | 200    | 250    | 250    | 400    |
| Labor    | 200    | 250    | 250    | 400    | 200    | 3750   | 1000   | 1150   |
| Total    | 200    | 250    | 250    | 400    | 200    | 3750   | 1000   | 1150   |

It is important to indicate that directing student project towards innovative technology and solutions still remain in the new curriculum. The existing key factors, such as technology focus, were successful portions in the existing curriculum.
The “theory in use” model was also used in this experiment. It became very effective in this testing, as a cluster evaluation was built in a networking learning model, to make reciprocal information flow. The student and instructors were able to learn to apply new components in the project development. A number of new improvements were developed during the experiment, and some were immediately applied into student project development for further testing. Successfully tested learning methods and models were immediately included into the curriculum enhancement.

When the curriculum enhancements were tested, qualitative and quantitative data from observation, survey, presentation, and report was collected and processed by statistical functions in Excel for further evaluations. It is important to indicate that the “Before Change” data was from a larger sample size than “After Change” data, because “After Change” data was collected from a pilot project with one student participation. After enhancements in new curriculum were tested through this pilot project, newly integrated project components, project management, evaluation process and report writing still remain to be tested with more students’ and instructors’ participations.

Although the survey could have been designed with emphasis on more subjective, context-bound open-ended type of questions, it still demonstrated several improvements, which were a result of the enhanced curriculum. One of survey results (see below) demonstrated a significant improvement in communication and presentation skills due to added management and facilitation of the student and instructor interaction, dialogical learning, conceptual innovation, and service delivery. Student’s problem solving and project management skills were also significantly improved in this project. The research hypothesis testing in controlled setting, with sufficient participations and data collection and delivery, were satisfactory.

Chart 1: Survey Results on Key Learning Components before and after Curriculum Change
The survey also validated the new model of student and instructor’s full involvement in decision making. It helped to gain invaluable first-hand experience and build foundation for expand the same curriculum testing with larger student and instructor population.

While a number of achievements were made by the support of survey analysis, other questionnaires and observation indicated that monitoring student’s project activities could have been enhanced with multiple means and methods. Additional internal workshops and public expert seminars should be added to newly developed curriculum. Higher standard should be set up for project reports, based on one survey results. Student’s final report should be encouraged to be published at conferences and even published at serial publications.

More research is needed, including observation, survey and evaluation, to refine definition of topics and design of research questions. Other improvements on survey technique were identified, and included selecting more candidates with different industry and geography consideration.

**Limitations of the Study**

The purpose of this paper was to only to introduce a pilot project to test the enhanced curriculum. The main aim was to test feasibility of the enhanced curriculum and train other faculty members. Only a few instructors, teaching assistants, and a selected student got involved in this experiment. Although the survey results proved that most of original goals had been achieved, it is still hard to predict the complete and accurate outcomes from the enhanced curriculum at this moment. It is still needs to be tested whether or not this curriculum enhancement will provide sufficient training opportunities for students to develop their skills and knowledge, in order to make them successful in their future professional career in the global economy. Nevertheless, preliminary test results from the junior student project were outstanding and encouraging. They proved the fact that high quality of student projects could help students master certain skills and develop student’s knowledge.

**Conclusion**

In summary, this research discovered a set of new components that need to be implemented in the existing engineering curriculum. The experiment on a student pilot project, with new focus on development of practical knowledge and human development skills, was successfully conducted. The unambiguous evaluation and assessment on student project design and planning, project process issue handling evaluation, and project management and monitoring, revealed empowerment of human development skills building. The output and outcome evaluation, based on student technical reporting and survey results, proved the new enhancements to the curriculum to be effective and could be used as the foundation of future curriculum improvement. It further proved that it was feasible to apply successful American higher education experiences in a Chinese higher education program. This new addition to an existing engineering curriculum not only set up a model for any closely related academic discipline in China, but also had its impact on other academic disciplines.
The authors would very much like to discuss the new components to the curriculum, instructor’s involvement, student’s roles in all activities, process of curriculum design and testing with the conference attendees for feedback and generation of further improvements.

Bibliography


